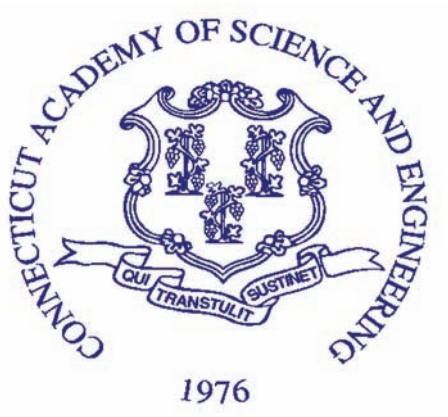
A Study of Weigh Station Technologies and Practices

November 2008

A Report By

The Connecticut Academy of Science and Engineering



For

The Connecticut Department of Transportation

A Study of Weigh Station Technologies and Practices

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The Connecticut Academy of Science and Engineering

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This study was initiated at the request of the Connecticut Department of Transportation on October 15, 2007. The project was conducted by an Academy Study Committee with the support of David Pines, PhD, Study Manager and Clara Fang, PhD, Study Consultant. The content of this report lies within the province of the Academy's Transportation Systems Technical Board. The report has been reviewed by Academy Members Peter G. Cable, PhD and Herbert S. Levinson, PE. Martha Sherman, the Academy's Managing Editor, edited the report. The report is hereby released with the approval of the Academy Council.

Richard H. Strauss
Executive Director

Disclaimer

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16. Abstract

This study was requested in response to concerns about the operation of the Greenwich Weigh and Inspection Station (Greenwich Station) on I-95 Northbound. The Station's configuration, combined with both the size and volume of trucks and buses (commercial vehicles) which must use it, severely impact the Station's ability to operate effectively to assure commercial vehicle compliance with the state's weight and safety regulations and requirements.

This report identifies technologies and practices that have the potential to increase the efficiency and effectiveness of weigh and inspection stations to deter the passage of overweight and unsafe vehicles across the state's highways; increase the transit efficiency for the large percentage of commercial vehicles that are compliant with Connecticut laws and regulations; and utilize information gathered through weigh system technologies for the multiple purposes of enforcement and transportation infrastructure decision-making and budgeting, including pavement design and highway maintenance and rehabilitation.

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CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

MEMBERS OF THE STUDY COMMITTEE ON WEIGH STATION TECHNOLOGIES AND PRACTICES

David Jones
Transportation Specialist
Federal Highway Administration

Tom Kearney
Truck Size and Weight Team
Federal Highway Administration

James Mahoney
Executive Program Director,
CT Transportation Institute &
Program Director/Head Research Engineer,
CT Advanced Pavement Laboratory
University of Connecticut

Louis Manzione, PhD *(Academy Member), Chairman*
Dean, College of Engineering,
Technology and Architecture
University of Hartford

Nejat Olgac, PhD *(Academy Member)*
Professor, Department of
Mechanical Engineering
University of Connecticut

Herbert Southgate
Kentucky Department of Transportation (ret)

Robert G. Wheeler, PhD *(Academy Member)*
Harold Hodgkinson Professor Emeritus of
Engineering & Applied Science, and
Professor of Physics
Yale University

George R. Wisner *(Academy Member)*
Principal
Wisner Associates

ConnDOT Technical Liaison

Anne-Marie McDonnell, P.E.
Transportation Engineer, Division of Research, ConnDOT

Research Team

Study Manager

David Pines, PhD, Associate Professor and
Chair of Civil, Environmental, and
Biomedical Engineering
University of Hartford

Study Consultant

Clara Fang, PhD, Assistant Professor,
Department of Civil Engineering,
University of Hartford

Academy Project Staff

Richard H. Strauss, Executive Director
Connecticut Academy of Science & Engineering
Phone: 860-527-2161
Email: rstrauss@ctcase.org

Ann G. Bertini, Assistant Director
for Programs
Connecticut Academy of Science & Engineering
Phone: 860-527-2161
Email: anngbertini@ctcase.org

EXECUTIVE SUMMARY

This study was requested in response to concerns about the operation of the Greenwich Weigh and Inspection Station (Greenwich Station) on I-95 Northbound. The Station's configuration, combined with both the size and volume of trucks and buses (commercial vehicles) which must use it, severely impacts the ability of enforcement personnel to operate the Station effectively to assure commercial vehicle compliance with the state's weight and safety regulations and requirements. During the Station's hours of operation, the queue of commercial vehicles rapidly extends into travel lanes on the highway, creating a potential safety concern. This commonly occurs within a 90-second period, requiring Station staff to close and open the Station throughout an operational shift. To eliminate this potential safety hazard, the Station is periodically closed, allowing commercial vehicles to legally bypass without being weighed or inspected. In addition to being a potential safety concern, the operation of undetected overweight commercial vehicles on Connecticut highways contributes to excessive road damage. This damage creates an increase in the frequency of road repairs and associated traffic delays, resulting in increased maintenance and user costs.

STUDY DESCRIPTION

The objective of the study is to provide a literature-based and best practices review of the current state of knowledge regarding weigh and inspection station technologies with respect to their application and consideration for use in Connecticut. The focus of the study is identification of technologies and practices that have the potential to increase the efficiency and effectiveness of weigh and inspection stations to deter the passage of overweight and unsafe vehicles across the state's highways; increase the transit efficiency for the large percentage of commercial vehicles that are compliant with Connecticut laws and regulations; and utilize information gathered through weigh system technologies for the multiple purposes of enforcement and transportation infrastructure decision-making and budgeting, including pavement design and highway maintenance and rehabilitation.

Review of Connecticut Weigh Station Operations, Weigh-In-Motion and Electronic Safety and Screening Technology, and Best Practices

This report includes a review of the design and operation of Connecticut's six permanent weigh and inspection stations and the extensive experience that the Connecticut Department of Transportation (ConnDOT), Department of Motor Vehicles (DMV), and Department of Public Safety (DPS) have using technologies such as weigh-in-motion (WIM) and electronic safety and credential screening ("e-screening") systems. Because of the regional issues associated with the efficient and effective operation of weigh and inspection stations, a review of how the Connecticut's neighboring states perform these functions is also provided. This is followed by a description and comparison of the mature WIM sensor technologies (piezoelectric, load cells, and bending plates) and a summary of a promising non-intrusive bridge WIM scale technology that has been used in Europe but not in the United States. A review of pertinent literature indicates that it is very evident that physical site conditions play a major role in the overall accuracy of WIM scales. Thus, a summary of the Standard Specification for Highway Weigh-

In-Motion Systems (ASTM E 1318-02) regarding the installation and site conditions required to meet the accuracy needed for enforcement purposes is also provided.

Additionally, a description of selected best practices that have been employed using WIM scales has been provided for review and consideration. This section includes a summary of the Federal Highway Administration's (FHWA) Long-Term Pavement Performance (LTPP) program regarding the evaluation of WIM sensor technologies and site conditions needed to meet design-level data requirements; the effective use of a WIM system used for enforcement purposes in Louisiana; the use of virtual weigh and inspection stations (see page xi for a description of virtual weigh and inspection stations) in Minnesota for both enforcement and data collection; and the data management system deployed in the Netherlands for maximum utilization of WIM and electronic screening data.

SUMMARY OF FINDINGS AND SUGGESTIONS

This summary provides an overview of the findings and suggestions section of the study report. The findings and suggestions identify several actions that are recommended for improving the efficiency and effectiveness of the state's commercial vehicle weight and inspection program, along with related activities that involve the collection and use of WIM information for other purposes. The Study Committee identified improvements to the Greenwich Station as the highest priority for the state's consideration. This overview approaches the findings and suggestions from the general to the more specific recommendations, including suggestions for improving the efficiency and effectiveness of the Greenwich Station.

Implementation of the study committee's suggestions and recommendations for the Greenwich Station and for the development of a Comprehensive Roadside System, including installation and the use of WIM and e-screening technologies for the state's network of permanent and portable weigh and inspection stations, is expected to achieve increased efficiency and effectiveness of the state's enforcement activities while at the same time serving to encourage commercial vehicle compliance with state requirements and regulations. The statewide network of mainline WIM and e-screening systems, especially at the Greenwich Station, will allow enforcement personnel to focus their attention on those vehicles most likely to be either overweight or with safety issues. This will provide for a more effective use of limited enforcement personnel resources, while also achieving state goals of improving the safety of commercial vehicles and the safety of the state's highways.

Development of a Statewide Comprehensive Roadside Network

Based upon a review of available information regarding WIM and electronic safety and credential screening technology as well as discussion with the ConnDOT, DMV and DPS staff, officials from other states, and members of the Study Committee, it is suggested that Connecticut develop a Comprehensive Roadside Network that combines the functions of credential verification, safety inspection, and weight enforcement with the goal of having a statewide system that is compatible with federal systems and neighboring states so data sharing can further increase the efficiency and effectiveness of commercial vehicle enforcement activities and the efficiency of the trucking industry in the Northeast. Additional high-speed mainline WIM sites beyond those needed for enforcement should be included to meet all of the state's data requirements, including research and planning. An important resource that should be

utilized in designing and implementing this statewide system is the FHWA Smart Roadside Initiative program. This comprehensive network will provide an opportunity to improve upon the efficiency gains that DPS and DMV have already realized through the installation of low-speed WIM scales at the Greenwich and Union Stations.

Benefits of a Comprehensive Roadside Network

The implementation of a Comprehensive Roadside Network will provide significant benefits to the state, including the following:

- Improved safety of commercial vehicles
- Safer highways
- Better protection of the state's highways and road assets
- Enhanced pavement research and design by having an improved data collection and management system that provides accurate truck volume, classification and weight data
- Possible reduction in premature failure of pavements as a result of the potential reduction of overweight vehicles operating on the state's highways
- Efficient movement of compliant commercial vehicles through the state and the region without delays and weigh and inspection station stops
- Reduction in productivity losses due to congestion as a result of lane closures required for premature highway maintenance and repair

Implementation, Operation, and Governance

It is suggested that a multi-agency task force ("Task Force") consisting of representatives from ConnDOT, DMV, and DPS be established that will be responsible for leading the design, operation, and maintenance of the Comprehensive Roadside Network. In addition, the Task Force shall be responsible for identifying annual goals and continually seeking to improve the effectiveness of the state's weigh and inspection program. It is suggested that one goal of the state's enforcement program should be a continual annual reduction in the number of citations/violations issued through a consistent enforcement effort that encourages compliance with weight and inspection requirements.

The full implementation of a Comprehensive Roadside Network will require a long-term plan with sufficient funding to meet each of the milestones identified by the Task Force. The plan should include at minimum the following:

- Prioritization of implementation of Comprehensive Roadside Network
- Identification of WIM scale and e-screening locations
    - Permanent Weigh and Inspection Stations
        - Review and consider retaining all permanent weigh and inspection station sites or converting some to virtual weigh and inspection stations

        - Keep existing layouts or modify stations to take advantage of efficiency improvements through the installation of high-speed mainline WIM scales and e-screening systems
    - Virtual Weigh and Inspection Stations
    - Pavement research and design requirements
    - Planning requirements
    - Site location considerations: availability of access to power and phone; adequate location for controller cabinet; adequate drainage; free flow traffic conditions; and minimal need for lane changing
- Selection of System Hardware
    - Compatibility with WIM scale and e-screening technology used at Union Station or consideration of next generation technology for all systems.
    - Promote and encourage the use of in-vehicle transponders for commercial vehicles to maximize participation in the e-screening system.
    - Incorporate the use of continuous automatic vehicle classification (AVC) systems on bypass routes in the vicinity of weigh stations
- Identification of WIM scale and e-screening data applications and users (including undertaking a regional effort to have all northeastern states provide data to the national Safety and Fitness Electronic Record (SAFER) system so that this data would then be available to all states)
    - Provides basis for software requirements and design of a fiber optic/wireless communication system
- Funding Requirements
    - Installation costs
    - Data management and software development
    - Operation and maintenance

The following sections summarize several key elements of the plan.

System Implementation

HIGHEST PRIORITY: GREENWICH STATION IMPROVEMENTS

Initially, the highest priority should be given to improving the efficiency and effectiveness of the operations of the Greenwich Station due to the significant number of commercial vehicles entering Connecticut from the State of New York. For Greenwich Station, it is suggested to

- Install a high-speed mainline WIM and e-screening system on I-95 in advance of the

Station for commercial vehicle screening to allow enforcement operations to focus efforts only on those vehicles suspected of being overweight or with credential or inspection issues, and possibly eliminate the low-speed WIM scale at the Station as a result of installation of the high-speed mainline WIM system.

- Consider lane reconfiguration from the New York border through the area of the Station to create four travel lanes, with the right lane serving as a "truck only" lane with all commercial vehicles being required to travel in the right lane until they are beyond the Greenwich Station.
- Conduct the planned site feasibility study for the purpose of maximizing the efficiency of the Station, including consideration of installing a hazardous materials off-loading area and an enclosed inspection facility, similar to those that are installed at the Union Station.

Regardless of the outcome of the Greenwich Station site feasibility study, the installation of a high-speed mainline WIM and an e-screening system at this location is most critical for achieving an acceptable level of operational capability at the Station. It is suggested that if this cannot be accomplished, then consideration should be given to seeking alternative locations for permanent and or virtual weigh and inspection stations in Fairfield County. The least attractive alternative is to maintain operations at the Greenwich Station under current conditions.

The design of the Greenwich Station WIM and e-screening system should be consistent with the technology being used at Union Station because the state has already invested in a mainline WIM and CVISN (Commercial Vehicle Information Systems and Networks) system at this location. It is very important that the state develop one system that meets the needs of all six permanent weigh and inspection stations rather than six individual systems using different types of technologies; that latter would make data communication difficult and result in no commonality concerning maintenance of the systems' hardware and software.

VIRTUAL WEIGH AND INSPECTION STATIONS

A virtual weigh and inspection station system includes components of a permanent weigh and inspection station, except that it does not include a permanent facility with a fixed static scale. A virtual weigh and inspection station system is intended to provide high-speed WIM system real-time weight, and e-screening data that enables enforcement personnel to focus their attention on portable static scale weighing operations and vehicle inspections for only those commercial vehicles that have been identified as being possibly overweight or having safety/inspection issues, and to allow all other vehicles to efficiently bypass virtual station operations.

Virtual weigh and inspection stations should be used to supplement enforcement and data collection at permanent weigh and inspection stations. Consideration should be given to locating high-speed mainline WIM scales that include an e-screening capability for virtual weigh and inspection stations at the same locations where portable weight scales are currently being used (see 2008 Connecticut Size and Weight Enforcement Plan). These sites meet the requirement of being able to safely stop trucks so they can be weighed using portable scales and inspected.

Analysis of data collected from the virtual weigh and inspection station high-speed mainline WIMs, as well as from the permanent weigh and inspection stations on a continuous basis, should be used for determining where and when to set up enforcement activities. Enforcement personnel must be able to access real-time data in a user-friendly format from the virtual WIM scales and the e-screening system so that they can effectively target commercial vehicles that are likely to be overweight and/or have safety violations.

ADDITIONAL WIM SITES FOR PLANNING, PAVEMENT RESEARCH, AND OTHER APPLICATIONS

WIM scale sites, in addition to the permanent and virtual weigh stations used for weight and inspection enforcement, may be necessary to collect the data needed by ConnDOT's Planning, Research and Pavement Management groups. Also, consideration should be given to developing WIM sites at additional key locations, such as at port, rail, air cargo, and major distribution centers; this could provide valuable data that will be helpful for highway design purposes to enable ConnDOT to have a better understanding of commercial vehicle trip operations, including freight movements.

These additional locations should be included in the network of WIM scales that continuously collect and send data to a central database. Because these WIM scales will not be tied to permanent or portable static scales, it will be necessary to calibrate these WIM scales at a minimum of once a year using trucks of known static weight. The calibration procedure should follow the same procedure as that used in the LTPP study. Furthermore, it is suggested that internal checks be included in the WIM system software algorithms and analyses that can provide a monitoring capability and an early warning as to the accuracy and potential malfunctioning of the WIM scale. These include comparison of the distribution of vehicle gross weights and verification that the front axle weight for unloaded FHWA Class 9 vehicles is within a lower and upper limit.

SUGGESTED WIM SCALE TECHNOLOGY

ConnDOT, DMV, and DPS have experience using quartz, bending plates, and load cell WIM scales, which are the most mature and proven technologies available. Because site conditions are such an important factor in determining the accuracy of the WIM scales, it is difficult to quantify which of the technologies provides the most accurate estimates of a vehicle's static weight. However, taking into account installation, maintenance, safety, and cost, it is suggested that Connecticut invest in the quartz piezoelectric technology for new and replacement WIM scale installations. This suggestion should be verified as the analysis of data from the LTPP Phase 2 study results becomes available to see if this technology still provides the best overall characteristics compared to the other WIM technologies. Furthermore, the use of three rows of quartz piezoelectric sensors versus the standard two-row configuration should be considered. The three-row configuration will initially be more expensive for purchase and installation. However it has the potential to reduce sensor life cycle cost as a result of a reduction in the highway smoothness necessary to attain the required accuracy needed for enforcement applications (i.e., Type III ASTM requirements).

Additionally, bridge WIM scales, a promising non-intrusive technology, should be considered as a supplement to quartz piezoelectric WIM scales to provide a more comprehensive WIM

network. Experience from research in Connecticut and other parts of the United States and Europe should be used to determine when the development of the bridge WIM technology is mature enough to meet Type III ASTM requirements.

WIM SCALE ACCURACY

The accuracy requirements of the WIM system will vary depending on the application (i.e., enforcement, pavement design, planning, research). WIM scales at a minimum should meet ASTM Type III requirements that are needed for the screening of commercial vehicles for enforcement purposes. WIM sensors must be able to provide consistent results in asphalt pavement under a wide range of temperature conditions. Proper site conditions and installation requirements must be met for the sensors to be able to perform as an effective screening tool. While maintenance requirements of the WIM scales in the road should be minimized for safety reasons, maintenance of required site conditions is necessary for ensuring required accuracy and must be included in the agency's budget.

The development of a quality assurance and quality control (QA/QC) system is imperative so that the WIM-scale network consistently provides data of the quality needed for effective enforcement, pavement design, planning and research. It is important that software should be developed or procured that will continually perform a statistical comparison of a commercial vehicle's static weight to the WIM scale's estimate of static weight. This requires that commercial vehicles be identified utilizing in-vehicle transponders or some other method of vehicle identification (e.g., cameras, inductor loops for measuring axle spacing).

DATA MANAGEMENT

The development of the comprehensive roadside network will require that software be developed and/or procured to meet a wide range of applications. Specifically, the data collected should automatically be stored in a database management system and be available in a format that meets the reporting requirements of all users.

CONCLUDING REMARKS

The overall benefits of a statewide network of high-speed mainline WIMs coupled with e-screening capability and a comprehensive virtual and permanent weigh and inspection station system, include encouraging commercial vehicle compliance with state regulations, improving the efficiency of weight and inspection program operations, and improving air quality. The state may also be able to utilize valuable information collected from the system's operation for highway pavement design purposes.